

# Preface

The central topic of this book is the coating and modification of high surface area materials using vapor phase deposition methods. This ability is a fundamental component of the nanomanufacturing toolbox, both at a research level, for instance to design of architectures and catalyst materials, and from a manufacturing point of view, as an integral component of semiconductor processing. It is also a field that has a long history that extends back to the 1960s in the early years of semiconductor processing, and even earlier, to the beginning of the twentieth century, if we include the fundamentals of heterogenous catalysis and rarefied gas flow. This diversity of applications and rich history makes it sometimes difficult for researchers in one area to take advantage of advances made in a different field: as much as research is becoming more interdisciplinary, a cursory look at the literature shows how discoveries and models have been re-discovered in different fields, or how problems that were once solved in a particular domain pop up later in a different place.

The purpose of this book is to bring together the fundamentals of the coating and functionalization of high surface area and nanostructure materials cutting across all these disciplines and application domains. The hope is that this book will be helpful to those interested in applying these techniques to fabricate new architectures or in developing new processes that can enable new materials and devices. I don't expect this book to be the definitive answer to this problem: due to the breadth of the subject and the limitations in space, it is impossible to explore in depth all of the topics included in this work, many of which would deserve their own books. Others didn't even make it into the manuscript. The same goes with the references included in this book: many outstanding examples in the literature had to be left out, including some of my personal favorites.

I have divided the material into five different chapters: Chap. 1 provides an introduction to the problem, including the range of substrates, growth techniques, and applications. Chapter 2 introduces the main deposition techniques, with a particular emphasis on those aspects that are relevant to the growth inside nanostructured or high surface area materials. Chapter 3 introduces the fundamentals of gas transport inside nanostructured materials: ballistic transport, diffusive models, and the impact of surface adsorption. Chapter 4 focuses on the application of these

models to understand the growth inside high surface area materials. In particular, it emphasizes the importance of Thiele modulus as the key parameter controlling the infiltration dynamics in both chemical vapor deposition and atomic layer deposition. The chapter also presents a criterion to achieve conformal deposition for a given surface kinetics. Finally, in Chap. 5 I introduce two separate aspects of the coating of high surface area materials: the first one are modeling approaches to shape and surface evolution in high surface area and nanostructured materials. The second one is the coupling between the pore size scale and the reactor scale to understand the impact that high surface area materials can have in the transport of materials inside thin film growth reactors.

The main motivation for writing this book has been my own research experience: moving across application domains and growth techniques in the area of thin films and nanomaterials has allowed me to explore the fundamentals of reactive transport inside nanostructured materials from different perspectives, and work with processes with vastly different surface kinetics. I also perceived a gap in the literature, a single point of reference for the topics treated in this book. My approach to this book and the choice of topics have also been strongly influenced by my training as a theoretical physicist: when it comes to developing new processes or transferring technology from research laboratories into manufacturing, I firmly believe that a better grasp of the fundamentals can help us understand how to best design or scale up a particular process.

Finally, I would like to acknowledge the Northwestern Argonne Institute of Science and Engineering for providing me with the right framework to write this book, a task that falls outside the scope of my work as a researcher at Argonne National Laboratory.

Northbrook, IL, USA  
June 2016

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Growth and Transport in Nanostructured Materials

Reactive Transport in PVD, CVD, and ALD

Yanguas-Gil, A.

2017, XI, 128 p. 57 illus., 20 illus. in color., Softcover

ISBN: 978-3-319-24670-3